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The Typhoon Kezia and Atmospherics

By Atsushi KIMPARA

Nagoya University (Read May 21, 1951)

Summary

The author proposes the consideration that the main origins of atmospherics are the symbol indicating the degree of disturbances in the conditional instability region, of which he confirmed the frontal type and the air mass type. This is not only justified on physics of the formation of atmospherics, discussing from the view point of electromagnetic waves and atmospheric electricity as well as from the meteorological point of view, but also it is confirmed by the observations actually made for years. In this paper the examples concerning the Typhoon Kezia are given and explained in detail. He found that origins of atmospherics concerning to this typhoon are destributed most frequently on the right hand side of the centre of the typhoon, especially on the perpendicular direction to the course, and they increase slowly with distance from the centre to 400 km, accompanying a small peak at 100 km, and at 400 km they reach maximum, and then decrease rather rapidly to 600 km.

1. The Condition of Generating Atmospherics.

Since the beginning[1] of our study on atmospherics in 1928, we have long been investigating the correlation of atmospherics with individual active weather phenomena such as thunderstorms, showers, typhoons, fronts, cyclones, cumulo-nimbus, etc., in observing their wave from[3] and at the same time in measuring their direction of arrival.[1][2][4][7] The origin of atmospherics, however, was located very often on the sea, where there are generally few meteorological observatories, and so it is sometimes difficult to make "one to one" correspondence between the origins of atmospherics and weather phenomena.

In these two or three years, however, documents, concerning upper atmosphere such as 3,000 m or 6,000 m high measured by airplanes or radio soundings, are available in addition to the ordinary meteorological data on the earth; the former informs us not only reliable meteorological situation on the sea or in the inlands, but also weather conditions correlated more intimately with the origin of atmospherics. According to the investigatigation made by O.H. Gish and H.G. Booker[6] on the ionization in the troposphere and lower stratosphere, it increases with the altitude above sea level till 15 km. Therefore, it is quite natural that disturbances in the upper

region are most intimately correlated with electrical phenomena, in particular with atmospherics.

Recently we studied carefully the correlation of atmospherics with the meteorological informations in the upper atmosphere, especially at 3,000 m high, and found that origins of atmospherics are mainly scattered over the conditional instability area liable to develop frontal thunderstorms or air-mass thunderstorms. The former occurs on account of instability released through ascent of air along frontal surfaces, the latter develops on account of instability within the air masses. Both are coincident in generating a strong current of warm and wet air masses which develops at least cumulo-nimbus; when it is more active, it generates showers or thunderstorms according to the degree of activity.

On the other hand, we observed from 1940 to 1944 many wave forms of atmospherics[3] originating from several kinds of lightning flashes and cumulo-nimbus. Lightning flashes, whatever they may be—discharge between clouds and earth, or among clouds—they are generally considered as some kinds of damped wave generator. Really, we find high frequency components in the discharging current of lightning flashes as shown in Fig. 1, and we find also light and dark stripes of some 100 μs intervals in the picture of lightning taken by Boy's camera. According to the analysis made on the observation of the wave from of atmospherics, the maximum energy is found to be concentrated in 7.5[3] to 10[5] kc/s, which is fairly well coincident with the frequency of main component of discharging current, and also with the stripe intervals of lightning pictures. These facts confirm us that the lightning flash is the most powerful origins of atmospherics as approved by many researchers for long. The shower is a similar kind but somewhat weaker disturbances than those of thunderstorms, and so it is very natural to consider the shower also to be the source of atmospherics, and, really, in our experience, we have found very often it is true. It is well known that cumulo-nimbus has a very strong electric field within it, at least between the top and the bottom; in consequence, there should be many random discharges between small drops of water within the cloud under the strong field.

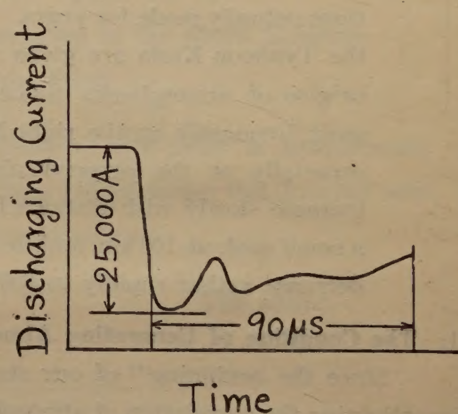


Fig. 1 The discharging current of lighting flashes.

In summer, when a warm and wet air mass is heated heavily by the radiated heat from the earth due to sunshine, we observe thunderstorms, showers, cumulo-nimbus, etc. of so called air mass type; and we observe corresponding atmospherics mainly on land. When a hot and wet air mass, blown by a heavy wind, strikes a slope of mountains, it generates a strong ascending air current and results cumulo-nimbus. This is one of another air mass type and it occurs often in the mountains in the tropical zone by the monsoon, and sometimes in Japan influenced by the ap-

proaching typhoon. In the other seasons, however, sometimes even in summer, convergence of two or more air masses of different characteristics occurs very often. They develop cold fronts, occluded fronts, some kinds of active warm fronts, and other similar disturbances. When they are very active we observe thunderstorms, showers, cumulo-nimbus, etc. of frontal type; corresponding atmospherics are always found on the convergence zones, and these are main atmospherics generally observed either on land or on the see all the year round.

2. Results and Interpretations.

Cathode ray direction finders with photographic camera are employed together with receivers of a straight amplification type with 126 db. gain. We shall pick up some examples among our observation made in 1950, and explain them after our interpretation.

(1) September 12, 1950. (11.01 to 13.02 JMT).

Origns of atmospherics are plotted on the weather chart of upper atmosphere at 700 mb., and wind directions, fronts and rain areas on the earth are also described as reference. (Fig. 2.). A high pressure is on the Pacific Ocean and the Typhoon Kezia is on the sea south-east of Kyūshū. We shall explain the origins of atmospherics in classifying in four groups, i.e. A, B, C and D.

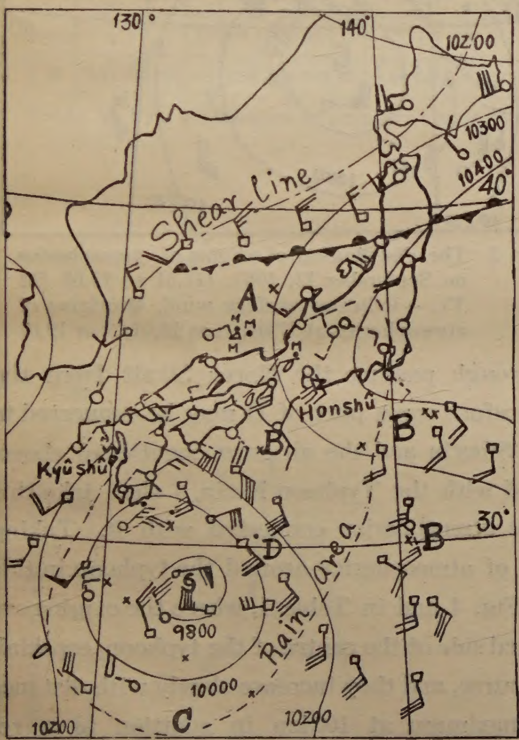


Fig. 2 The distribution of origins of atmospherics on September 12, 1950. (11.01 to 13.02 JMT). ---indicates surface wind, ×origins of atmospherics at 11.01, ● at 11.31, and △ at 12.31.

B and D are generated in the convergence area of the warm and wet air mass coming from the high pressure region on the North Pacific Ocean and the hot and wet air mass coming from the tropical zone accompanied by the Typhoon Kezia. A is generated in the convergence zone made by these hot and wet air in ascending above the côld air coming from Siberia by way of the Japan Sea. In fact, at Kanazawa (in A region) cumulo-nimbus and thunderbolts were observed, and at Shionomisaki (in B region) cumulo-nimbus. In D region the wind velocity in 700 mb. layer was so large as to reach 30 to 40 m/s, and the disturbance is considered to be very heavy there. C is generated by the contact of the hot and wet air mass accompanied by the typhoon with the warm and dry air mass from China. At Yakujima (in C region) showers are observed, and at Naze (in C region) cumulo-nimbus.

(2) September 12, 1950. (17.01 to 19.02 JMT).

Origins of atmospherics are plotted in the same way as in case (1). A high pressure is on the Pacific Ocean and the Typhoon Kezia is on the sea south-east of Kyūshū. (Fig. 3.). Origins of atomspherics are classified in four groups, i.e. A, B, C and D.

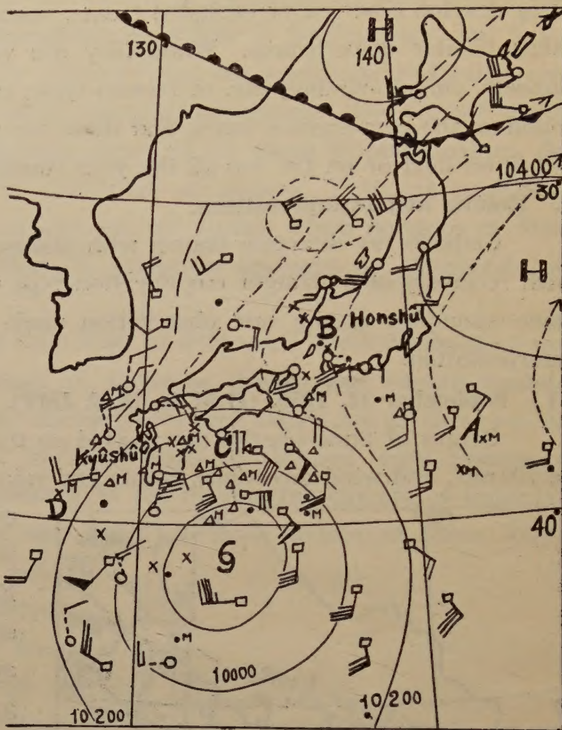


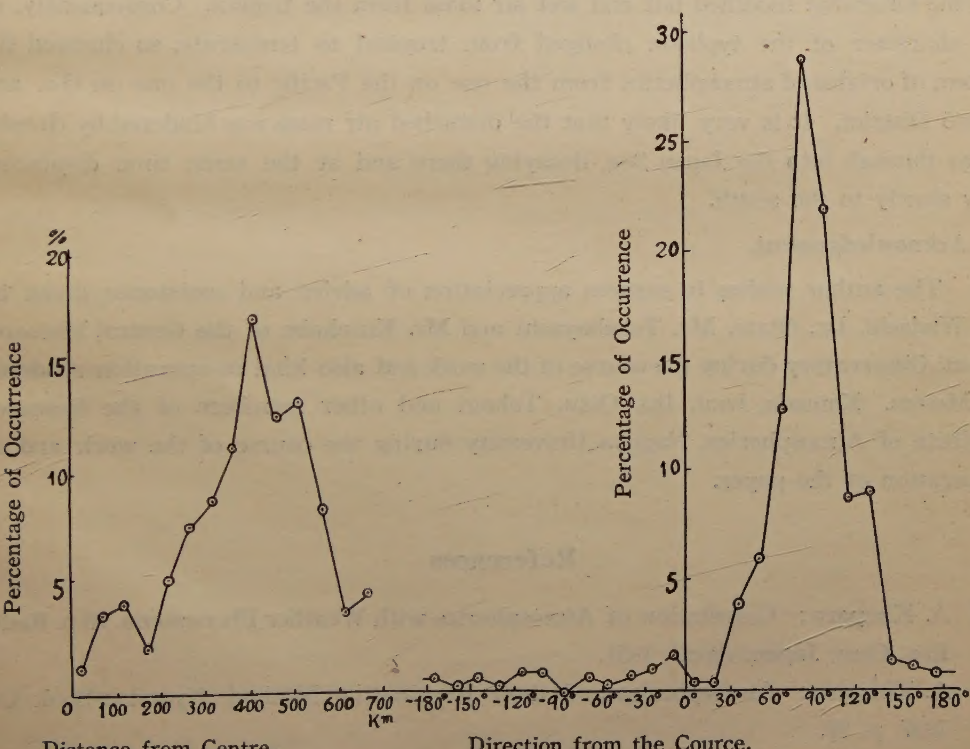
Fig. 3 The distribution of origins of atmospherics on September 12, 1950. (17.01 to 19.02 JMT). ---indicates surface wind, ● origins of atmospherics at 17.01, △ at 18.01, × at 19.01

A and C are generated in the convergence area of the warm and wet air mass coming from the high pressure region on the North Pacific Ocean and the hot and wet air mass coming from the tropical zone accompanied by the Typhoon Kezia; in particular, in C region the wind velocity is very high, i.e. 30 to 40 m/s, and consequently the disturbance is taken to be very strong there. B is generated in the convergence zone made by the hot and wet air in ascending above the cold air coming from Siberia across the Japan Sea. D is mainly due to the convergence of the warm and dry air mass coming from China and the hot and wet air mass of the typhoon, but there is a through passing the Korea Strait from the Japan Sea to the East China Sea, and therefore some part of D may be connected to the convergence of the cold air mass from Siberia and the air mass mentioned above.

These two examples being connected with the Typhoon Kezia, I shall take this opportunity to make some remarks on the atmospherics connected with it. Taking statistically the distribution of the origin of atmospherics around the typhoon in this occasion, we obtain the results shown in Fig. 4 and in Table 1, where the origins are distributed most frequently on the right hand side of the centre of the typhoon, especially on the perpendicular direction to the course, and they increase slowly with distance from centre to 400 km, showing a small maximum at 100 km in addition to a remarkable one at 400 km and then decrease rather rapidly to 600 km. In the Typhoon Kitty[8] the distribution of the wind velocity at 3,000 m and 6,000 m high has almost the same tendency with the distribution of origins of atmospherics in our case, and it has maximum at the distance between 300 to 400 km from the centre. As the Kezia came to Japan about the same season, if we assume almost the same construction for the Kizia as is usually the case, the most frequent distribution of the origin of atmospherics may be considered as the indication of the most active part of them.

	0	15	30	45	60	75	90	105	120	135	150	165	180	-165	-150	-135	-120	-105	-90	-75	-60	-45	-30	-15	Total	%
0–50									1				1			1	1								4	1.4
50–100			2	2	1	2	1							1	1					1					11	3.8
100–150		1	1	1	3	2														1	1	1		1	12	4.2
150–200				2		1		1		1	1														6	2.1
200–250				2	4	2	1		1								2	1					1	1	15	5.2
250–300				1	10	4	4		1									1					1		22	7.6
300–350			3	3	5	5	6	1										1				1			25	8.7
350–400	1		2	2	6	6	10		2						1									2	32	11.1
400–450			3	2	5	23	7	5	3	1															49	17.0
450–500				1	1	12	10	6	3	1	2														36	17.5
500–550				1	1	10	13	4	6			1											1	1	38	13.2
550–600						8	9	4	2				1												24	8.3
600–650						4	1	4	2																11	3.8
650–					1	4	1		5	1		1													13	4.5
Total	1	1	11	17	37	83	63	25	26	4	3	2	2	1	2	1	3	3		2	1	2	3	5	298	
%	0.3	0.3	3.8	5.9	12.8	28.9	21.8	8.7	9.0	1.4	1.0	0.7	0.7	0.3	0.7	0.3	1.0	1.0		0.7	0.3	0.7	1.0	1.7		

Table. 1. The distribution of origins of atmospherics in the neighbourhood of the Typhoon Kezia.



Distance from Centre. Direction from the Cource.

Fig. 4 The distribution of origins of atmospherics in the neighbourhood of the Typhoon Kezia.

As T. Otani and others noticed, in the neighbourhood of Japan there are always so heavy convergence phenomena of the hot and wet air mass from the tropics on the narrow area subtended by the high pressure on the Pacific and the centre of the typhoon

and also due to contact with the cold air mass from the north, and so there should be concentrated distribution of origins of atmospherics in the right hand side of typhoon. Consequently, the distinguished peak at the $+90^\circ$ point of the diagram in Fig. 4 is interpreted very naturally according to the heavy disturbances there. Morever, as shown in Fig. 2 and 3, simple continuous rain areas have no connection with origins of atmospherics.

The Typhoon Kezia seems to have changed its character after passing Kyūshū. At 18.01 JMT, September 13, when it was crossing Kyūshū, origins of atmospherics were off the coast of Shikoku on the Pacific Ocean. As the typhoon advanced and went into the Japan Sea, origins of atmospherics were found to be gradually weakened, and we can notice it clearly by the observations at 23.01 JMT, September 13- ; 08.01 JMT, September 14- ; and 12.01 JMT, September 14, when the typhoon reached at the point 40°N, 135°E on the Japan Sea, new origins of atmospherics appeared on the southern part of O-u District, northern part of Honshū, and on the northern part of Kantō District mainly on mountain slopes. Origins on the Pacific Ocean are considered mainly due to the convergence of the hot and wet air mass from the tropics and the warm and wet air mass from the high pressure on the Pacific, while origins on the Japan Sea due to the convergence of the cold air mass from Siberia and the somewhat modified hot and wet air mass from the tropics. Consequently, as the character of the typhoon changed from tropical to temperate, so changed the system of origins of atmospherics from the one on the Pacific to the one on O-u and Kantō District. It is very likely that the disturbed air mass was hindered by Honshū to go through into the Japan Sea, decaying there and at the same time displacing very slowly to the south.

3. Acknowledgement.

The author wishes to express appreciation of advice and assistance given by Dr. Wadachi, Dr. Otani, Mr. Tosabayashi and Mr. Kusakabe of the Central Meteorological Observatory during the course of the work and also kind co-operation rendered by Messrs. Kamada, Iwai, Ito, Otsu, Takagi and other members of the Research Institute of Atmospherics, Nagoya University during the course of the work and in prepsration of the paper.

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A Comparison of the Electron Density Variations in the F2 Region at Kokubunji and Yamagawa during the Night

By T. YONEZAWA

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Abstract

By comparing the electron density variations in the F2 region during the night at Kokubunji and Yamagawa it has been made clear that, if we assume a linear law of electron disappearance and somewhat higher temperature of the upper atmosphere at Yamagawa than at Kokubunji, the observational data fit theoretical expectation rather well, but a quadratic law can hardly be reconciled with the observations, unless recombination coefficient changes markedly with height.

1. Introduction

In a previous report[1] we made an analysis of the electron density variations during the night at Kokubunji and at Washington and revealed that electrons disappear more probably according to a linear law rather than a quadratic one. We have now made a further study along the same line by comparing the electron density variations in the F2 region during the night at two sites separated not very far from each other, namely at Kokubunji (35°42.4′ N, 139°29.3′ E) and at Yamagawa (31°12.5′ N, 130°37.7′ E), and the conclusion of the previous paper has again been confirmed. As a by-product we have also obtained a result that the upper atmospheric temperature above Yamagawa is probably somewhat higher than that above Kokubunji.

2. Method

The electron density variation during the night is governed by the following equation, if we adopt the linear law of electron disappearance:

$$\frac{1}{N}\frac{dN}{dt}=-B_0 e^{-\frac{z_m-z_0}{H}}-\frac{1}{T}\frac{dT}{dt}, \tag{1}$$

where N is the electron density, t is the time, B_0 is the attachment coefficient multiplied by the density, at a standard height z_0, of atoms and molecules to which electrons attach themselves, z_m is the height of the level considered, H is the local scale height and T is the absolute temperature. In the following we shall take the maximum electron density of the F2 region as N and h_p as z_m. Writing down Eq. (1) for Kokubunji and Yamagawa and taking the differences of the both sides, we obtain

$$\frac{d}{dt}ln\frac{N_2}{N_1}=-B_0\left(e^{-\frac{z_{m2}-z_0}{H_2}}-e^{-\frac{z_{m1}-z_0}{H_1}}\right)+\text{const.}$$

$$\simeq B_0\left(\frac{z_{m2}}{H_2}-\frac{z_{m1}}{H_1}\right)-B_0 z_0\left(\frac{1}{H_2}-\frac{1}{H_1}\right)+\text{const.}, \tag{2}$$

where we have assumed that the *relative* temperature variation is the same at both sites (in this case, const.$=0$) or the temperature decrease is exponential, and where the letters with subscripts 1 and 2 denote the quantities at Kokubunji and Yamagawa, respectively; B_0 is also assumed to be the same at the both stations.

Now, if the difference between H_1 and H_2 is not large compared with H_1 and H_2 themselves we can replace H_1 and H_2 with their average value $\bar{H}$ in Eq. (2) to a very rough approximation and obtain

$$\frac{d}{dt}\Delta\, ln\, N\simeq\frac{B_0}{\bar{H}}\Delta z_m+\text{const.}, \tag{3}$$

$$\Delta z_m\equiv z_{m2}-z_{m1}, \tag{4}$$

$$\Delta\, ln\, N\equiv ln\, N_2-ln\, N_1. \tag{5}$$

Eq. (3) shows that there should be a linear relation between $\frac{d}{dt}\Delta\, ln\, N$ and Δz_m, if time variation of $\bar{H}$ (or H_1 and H_2) is neglected. This is roughly the case as will be described in the next section, which seems to indicate that the method of analysis here adopted is not very unreasonable.

On the other hand, if electrons disappear by recombination, we shall be led to the following equation by a similar analysis:

$$\frac{d}{dt}\Delta\, ln\, N\simeq-\alpha\Delta N+\text{const.}, \tag{6}$$

$$\Delta N\equiv N_2-N_1, \tag{7}$$

where α is the recombination coefficient which is assumed not to change markedly with height, as may be expected on theoretical grounds. But Eq. (6) can not be verified by observation (cf. § 3).

Having thus established the approximate correctness of our analysis, we have then fitted Eq. (2) to observational data. If time variations of H_1 and H_2 are neglected as before, Eq. (2) becomes

$$\frac{d}{dt}\Delta\, ln\, N\simeq\frac{B_0}{H_2}z_{m2}-\frac{B_0}{H_1}z_{m1}+\text{const.} \tag{8}$$

Using the observational data of $\Delta\, ln\, N$, z_{m2} and z_{m1}, we can determine the most probable values of parameters B_0/H_1 and B_0/H_2 by the method of least squares, and from these we can obtain the ratio between the absolute temperatures of the upper atmosphere above Kokubunji and Yamagawa, for the scale height H is proportional to the absolute temperature.

3. Results and discussions

Using median values of observational data for respective months we have calculated the values of $\frac{d}{dt}\Delta\, ln\, N$ by numerical differentiation and plotted them (abscissa) against Δh_p (ordinate) in Fig. 1, (a)—(f) for some months in 1949. The

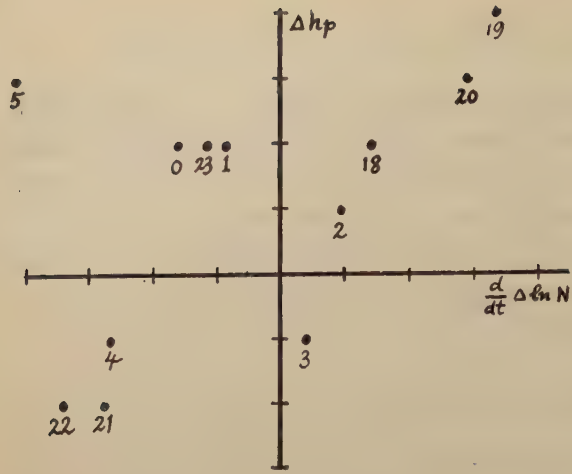

Fig. 1 (a) January, 1949

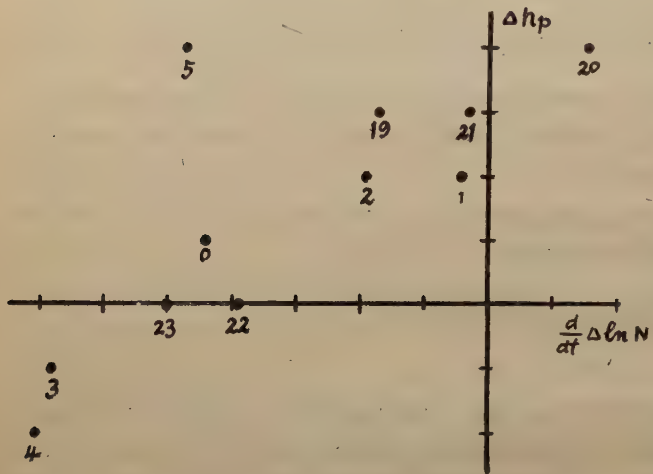

Fig. 1 (b) February, 1949

scales of both axes are arbitrary; the numbers attached to respective points in the figures show the hours of observation (J.S.T.).

We can see from these figures that in winter these points arrange themselves roughly along straight lines, with the exception of points corresponding to hours near sunrise or sunset. This exception is not surprising in view of the fact that we can not obtain accurate values of $\frac{d}{dt}\Delta \ln N$ by numerical differentiation near sunrise or sunset (especially near the former) owing to the rapid change in slope of the diurnal variation curve of electron density. On the other hand, linear relation does not so well hold between $\frac{d}{dt}\Delta \ln N$ and Δh_p for other seasons. It seems that this is, on the one hand, because the height determination in the ionospheric sounding is subject to not small errors, sometimes as high as 10km., so that the difference in height between two stations may be, in unfavourable cases, in error by about 20km., but, on the other, because height

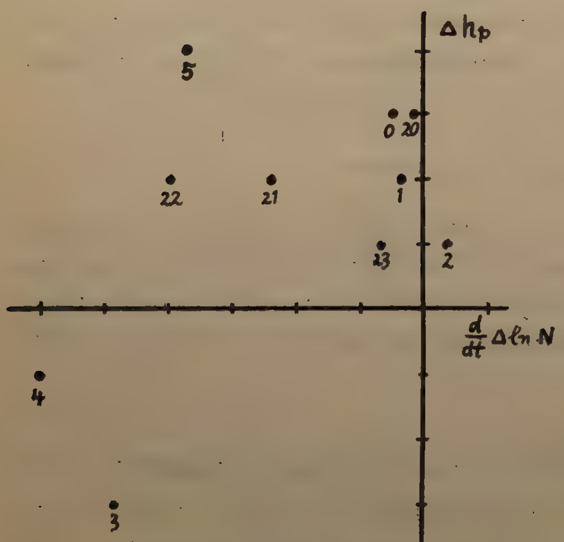

Fig. 1 (c) March, 1949

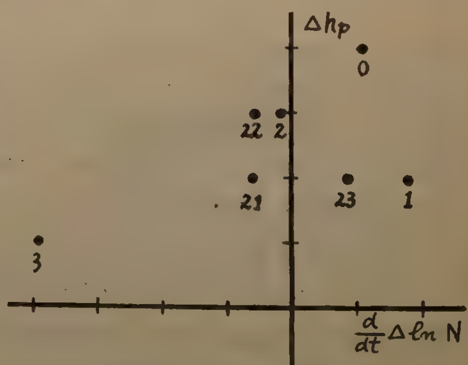

Fig 1 (d) June, 1949

change of the F2 layer is not very great in seasons other than winter. In view of these disturbing factors it will not be far from truth that the linear relation between $\frac{d}{dt}\Delta \ln N$ and Δh_p is also existing for seasons other than winter. An evidence for this may be provided by the fact that, if we take a weighted running average of h_p instead of h_p itself for each hour, the linear relation becomes much more clear as shown in Fig. 2 for June, 1949.

Now, if recombination theory is correct, there must be a linear relation between $\frac{d}{dt}\Delta \ln N$ and ΔN, and the correlation must be negative, as shown in Eq. (6). So an examination was made of this relation, and an example of its results is shown in Fig. 3 (February, 1949). We can see from the figure that the points are scattering more widely than in the corresponding Fig. 1 (b). But, what is more important, the correlation, if existing at all, is rather positive than negative, which contradicts the expectation from Eq. (6). Thus we can hardly support the recombination theory for electron dissipation during the night.

Entering into more details, we have then fitted Eq. (8) to observational data and determined the most probable values of B_0/H_2 and B_0/H_1. In view of the above described facts, good results will not be expected except for winter. This was indeed the case. But in no case we have obtained

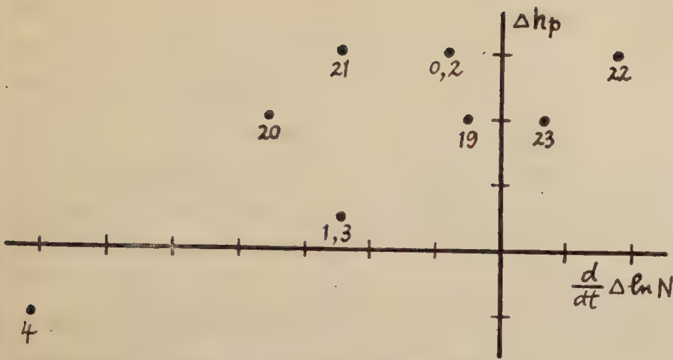

Fig. 1 (e) September, 1949

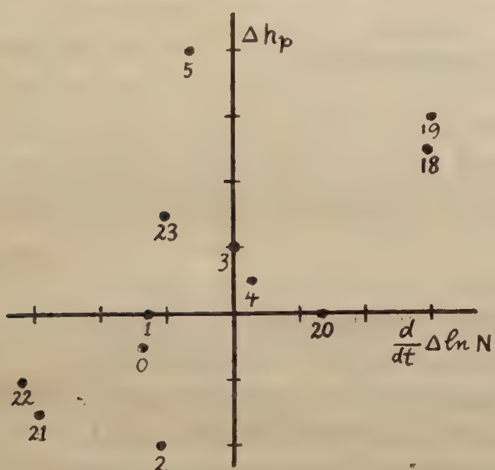

Fig. 1 (f) December, 1949

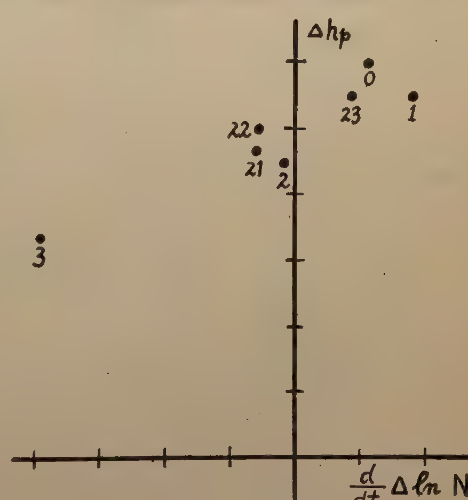

Fig. 2 June, 1949
(Weighted running mean of Δh_p is used)

very unreasonable values, such as negative ones, for these parameters. The ratio $H_2:H_1$ was 1.8, 1.6, and 2.0 for January, February, and December, 1949, respectively. In other seasons also this ratio had a tendency to be larger than 1, the average of all (including the above mentioned) being 1.9. Though we it can not place much weight on these figures, it is interesting to note that the result of analysis indicates higher upper atmospheric temperatures at Yamagawa (31°12.5′ N) than at Kokubunji (35°42.4′ N), which is consistent with our expectation.

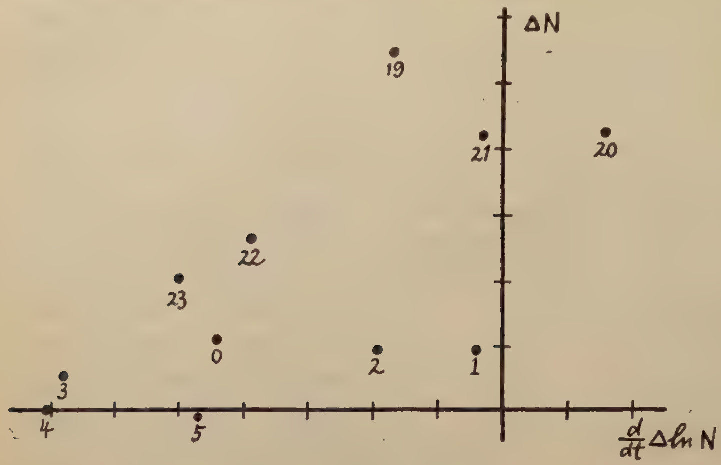

Fig. 3 February, 1949

4. Conclusion

Thus the comparison of nocturnal electron density variations at Kokubunji and Yamagawa showed that electrons disappear in the F2 region according to a linear law rather than a quadratic one, and the temperature of the upper atmosphere is somewhat higher at Yamagawa than at Kokubunji. But, in view of the limit of accuracy of height determination in ionospheric sounding, we can not hope to draw any quantitative deductions from such an analysis, and we must wait until more accurate data become available.

[1] T. Yonezawa, Rep. Ionosphere Res. Japan, 5, 1 (1951)

Localization of Atmospherics and Their Relation to Meteorological Phenomena

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Abstract

We equipped cathode-ray direction-finders on three observation stations which were situated on the end-points of the long base lines, and made simultaneous recordings of atmospherics bearing on photographic film. With these records we located atmospherics sources over a wide region which includes the tropical zone.

Comparing the distribution of atmospherics sources with meteorological phenomena, we get the following results:

1. Atmospherics received stationarily in Japan are usually generated by the thunderstorms which occur in South-east Asia, Australia and India.
2. In the region to the north of the 60°N line, we can scarcely find the atmospherics source.
3. In the temperate region, including Japan, atmospherics are observed to be accompanied with thunderstorms frontal, lines and depressions.

Observation Methods and Equipments

The observation periods, the name of observation points and the distance among them are as follows:

1st Observation (from 12th to 18th, May, 1950)

Yonago City—Kiyose Village (in the suburbs of Tokyo)	570 km
Yanago City—Niigata City	580 km
Niigata City—Kiyose Village	250 km

2nd Observation (from 23rd to 29th, Sep., 1950)

3rd Observation (from 12th to 19th, Jan., 1951)

Asahigawa City—Kiyose Village	900 km
Kiyose Village—Fukuoka City	880 km
Fukuoka City—Asahigawa City	1500 km

Observations were four times a day namely at 0900, 1200, 1500, 2100 (J.S.T.) and each observation took 10 minutes.

Main characteristics of the cathode-ray direction-finder and the method of recording are as follows:

Antenna: 1 meter square, 400 turn, (Effective Height 12 cm)

Amplifier: 3 stage straight amplifier (Gain 90 db)

Tunning Frequency: 12 KC

Sweeping Velocity of Film: 2 mm/sec

Time Signal: J.J.Y. Standard Wave

Having gathered the records thus obtained in three respective observation points, we determined the distribution of each atmospherics source with triangulation.

Outline of the Results

One instance of the distribution of the intersection points in the 1st observation period is shown in Fig. 1. As the base line between Kiyose Village and Niigata City was not long enough, it was difficult to locate very remote atmospherics sources in the east or west of Japan.

In the 2nd and 3rd observation periods we extended the base lines, and could locate the sources in so far regions as India. An instance is shown in Fig. 2.

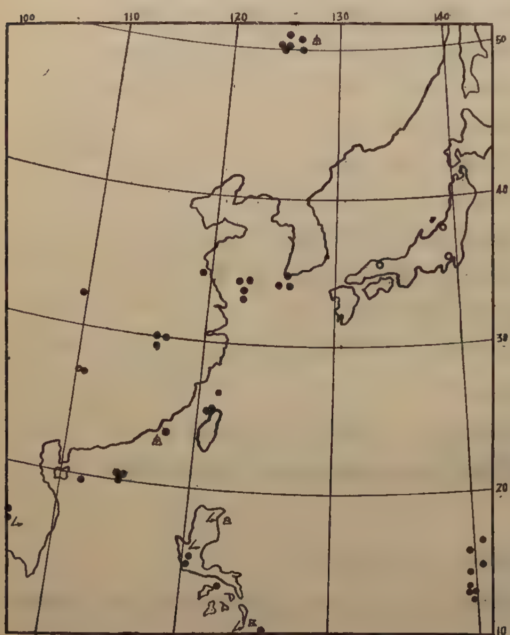

Fig. 1 Distribution of atmospherics sources, 2100, 12th, May, 1950
○ represents observation points:
● represents intersection points:
Lightnings and Cumulo-nimbus during the same time are shown.

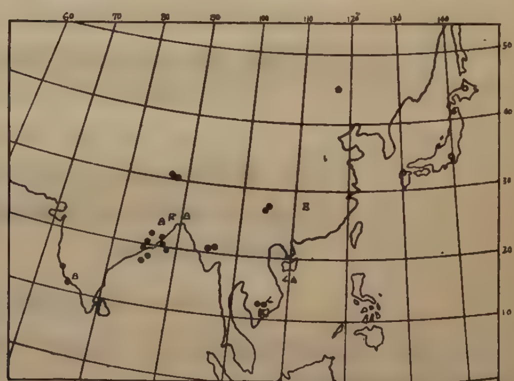

Fig. 2 Distribution of atmospherics sources, 2100, 24th, Sept., 1950
○ represents observvtion points:
● represents intersection points:
Lightnings and Cumulo-nimbus during the same time are shown.

In summer 60% of atmospherics sources are distributed in such tropical regions as Philippine Islands, Indo-china, Malay, Java, Sumatora, India, New Guinea, Australia etc. and in winter this percentage varies to 90%. The remains of atmospherics sources are distributed over the temperate regions including Japan. In any observation we scarcely find theatm ospherics sources in the region to the north of 60°N line.

Atmospherics from the Tropical Regions

We have collected meteorological reports communicated from the tropical regions mentioned above.

We compiled the reports of lightnings observed during the same time as our atmospherics observation, and examined the existence of the intersection points which corresponded to the reports of lightnings.

The results are shown in the following table.

Region	Number of Times When Lightnings Were Reported	Number of Times When Corresponding Points Existed
The Philippine Island	16	16
Indo-china, Malay	9	9
India	4	4

When we compiled the reports of Cumulo-nimbus, the results are as follows:

Region	Number of Times When Cunb. Were Reported	Nnmber of Times When Corresponding Points Existed
The Philippine Islands	8	2
Indo-china, Malay	4	3
India	2	2

With these results we find the fact that in these remote regions atmospherics sources are always recorded on the vicinity where lightnings occur and that they are not always recorded when only Cumulo-nimbus are reported. Considering the sparsity of the meteorological reports from these regions, it is probable that lightnings should exist when only Cumulo-nimbus are reported. Consequently we may conclude that the atmospherics observed to be in these remote regions are usually generated with lightnings.

Atmospherics in the Temperate Regions

We collected the results in which the atmospherics sources were observed to be concentrated in the temperate regions including Japan, and classified them by the districts. When we applied this method to the results of the 2nd observation period, we got the following table. The figures represent the number of atmospherics sources observed in 10 minutes, and the figures in the parentheses show their position by longitude and latitude. We also show the meteorological phenomena in the respective position with the following notations:

Low.—Depression	C.F.—Cold front	S.F.—Stagnant front	S.S.—Snow shower
T.—Thunderstorm	L.—Lightning	D.S.—Dust storm	

Date	Time (J.S.T.)	Region Near the Ogasawara Islands	Region Near West Hokkaido and Akita Prefecture	Manchuria
23	15	$3\binom{145\mathrm{E}}{20\text{-}25\mathrm{N}}2\binom{140\mathrm{E}}{30\mathrm{N}}$ Low		
24	12	$5\binom{140\text{-}145\mathrm{E}}{25\mathrm{N}}$ C.F.	$1\binom{138\mathrm{E}}{40\mathrm{E}}$ Low	
〃	15	$4\binom{140\text{-}145\mathrm{E}}{28\mathrm{N}}$ C.F.	$6\binom{138\mathrm{E}}{38\text{-}40\mathrm{N}}$ Low	
〃	21	$2\binom{145\mathrm{E}}{32\mathrm{N}}$ Low		
25	12	$4\binom{143\mathrm{E}}{25\text{-}30\mathrm{N}}$ C.F.		$11\binom{120\text{-}130\mathrm{E}}{45\text{-}50\mathrm{N}}$ Low
〃	15	$2\binom{143\mathrm{E}}{23\mathrm{N}}$ C.F.		
26	9	$5\binom{143\mathrm{E}}{30\mathrm{N}}$ C.F.		
〃	15	$10\binom{140\text{-}145\mathrm{E}}{20\text{-}30\mathrm{N}}$ C.F.		
〃	21	$3\binom{140\text{-}150\mathrm{E}}{30\mathrm{N}}$ C.F.		
27	15	$4\binom{150\mathrm{E}}{30\mathrm{N}}$ C.F.	$2\binom{140\mathrm{E}}{40\mathrm{N}}$ T	
28	9	$5\binom{140\mathrm{E}}{23\text{-}27\mathrm{N}}$	$3\binom{130\mathrm{E}}{43\mathrm{N}}$ T	
〃	15	$4\binom{138\mathrm{E}}{28\mathrm{N}}4\binom{143\mathrm{E}}{30\mathrm{N}}$		
29	9	$5\binom{140\mathrm{E}}{28\text{-}32\mathrm{N}}$ C.F.	$3\binom{140\mathrm{E}}{45\mathrm{N}}$	
〃	12	$10\binom{140\text{-}145\mathrm{E}}{30\mathrm{N}}$ C.F.	$1\binom{140\mathrm{E}}{43\mathrm{N}}$	
〃	15	$8\binom{140\text{-}150\mathrm{E}}{28\mathrm{N}}$	$9\binom{142\mathrm{E}}{40\text{-}45\mathrm{N}}$ T	$2\binom{127\mathrm{E}}{40\mathrm{N}}$ C.F.
〃	21	$1\binom{142\mathrm{E}}{30\mathrm{N}}$	$5\binom{145\mathrm{E}}{45\mathrm{N}}$ T	$3\binom{130\mathrm{E}}{40\mathrm{N}}$ C.F.

During the whole 2nd observation period, the cold fronts lay usually over the ocean in the south of Japan.

In such cases the atmospherics sources were observed to be concentrated in one or more points along them. When a cold front or a depression on frontal lines appeared in the south Manchuria area, the corresponding atmospherics sources were observed on 25th, 26th and 29th, Sept., 1950. The thunderstorm occurred in the west coast of Hokkaido when the frontal lines were passing on 27th, 28th and 29th, Sept., 1950. The corresponding atmospherics sources were observed distinctly. We can say that the depression and the frontal line do not always accompany the atmospherics but have a tendency to generate atmospherics when they arrive on some fixed regions.

During the 3rd observation period we also got the following table.

Date	Time (J.S.T.)	Region Near Formosa and Okinawa	Region to the North of Marcus	Region to the South of Kanto District	Coast of the Japan Sea
13	9				4(135E 36N) S.S.
14	15		4(150-155E 25-30N) C.F.		
15	9		4(155E 25-30N) C.F.		
〃	12		3(145-150E 25 30N) C.F.		
16	15	13(125-130E 20-25N) Low			
〃	21		8(155-160E 30-35N) Low		
17	9		6(160-165E 25-30N) Low		
〃	12		1(160E 30N)	4(138E 33N) S.F.	
〃	15	15(125-130E 25-30N) T. D.S.		3(138E 33N) S.F.	
〃	21			6(138E 33N) S.F. L.	
18	12	5(135E 25N)	3(160E 30N) Low		
18	21		4(160E 30 35N) Low		
19	12			3(140E 35-38N) Low	

During this observation period a weak cold wave have happened, and brought snow showers in the coast of the Japan Sea from 12th to 14th, Jan., 1951. Atmospherics due to this shower were recorded in the observation as 0900. Thunderstorms occurred twice during the night, one on 17th was caused by a stagnant front (Fig. 3) and the other on 19th by a depression. In both cases atmospherics were recorded at early part of the day.

In the region near Formosa and the Okinawa Islands many atmospherics sources were observed on 16th, 17th and 18th, Jan., 1951. This is the region where depressions are frequently generated. According to the weather map, a depression was actually generated on 16th, Jan., 1951. On 18th, Jan., 1951 the isobar did not close over this region but the wind distribution suggested that a cyclonic disturbance might

occur there. (Fig. 4). On 17th, Jan., 1951 the isobar showed no characteristic feature but thunderstorms and dust storms happened there during the night. (Fig. 3) We

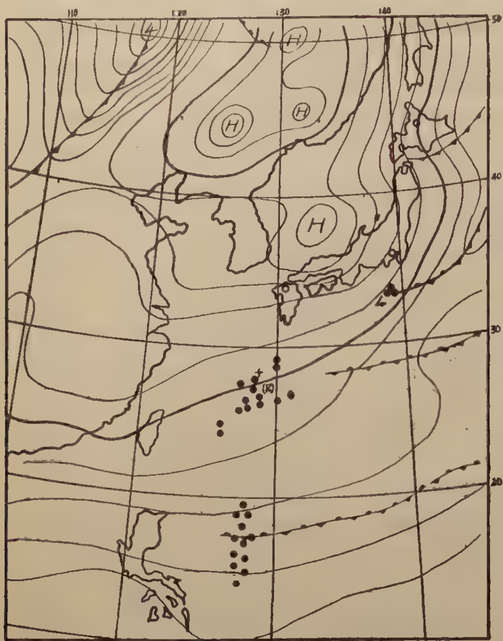

Fig. 3 Distribution of atmospherics sources and synoptic situation 1500, 17th, Jan., 1951. As for Lightnings and Dust storms, the one observed till 2100 are shown.

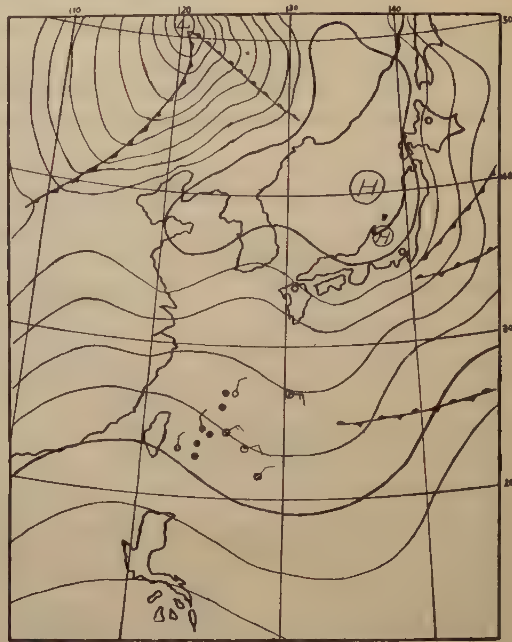

Fig. 4 Distribution of atmospherics sources and synoptic situation 1200, 18th, Jan., 1951. Wind distribution near atmospherics sources are shown.

observed also many atmospherics sources in the region to the north of Marcus Island 8 different times during this observation period. These sources always corresponded to a cold front or a depression on frontal lines. The distribution of the sources is very similar to the case observed in the region near the Ogasawara Islands in the 2nd observation period.

This region was a triple point, surrounded by Siberia, Okhotsk and Ogasawara air masses and was a field of cyclogenesis in that period. Consequently we consider that when depressions or frontal lines reached this region, they developed again and generated atmospherics.

Atmospherics Accompanied with a Typhoon

In the 1st observation period a typhoon appeared in the south-west Pacific Ocean and moved to the north taking the course illustrated in Fig. 5. Atmospherics sources observed in its active area are shown in the following table.

Date	(J.S.T.) Time	Number of Atmospherics Sources Observed in 10 Minutes	Pressure of Center of Typhoon in mb.
12	9	34	940
〃	12	10	

〃	15	No Observation	940
〃	21	6	
13	9	No Observation	
〃	12	12	940
〃	15	No Observation	950
〃	21	17	
14	9	0	
〃	12	4	950
〃	15	No Observation	960
〃	21	0	

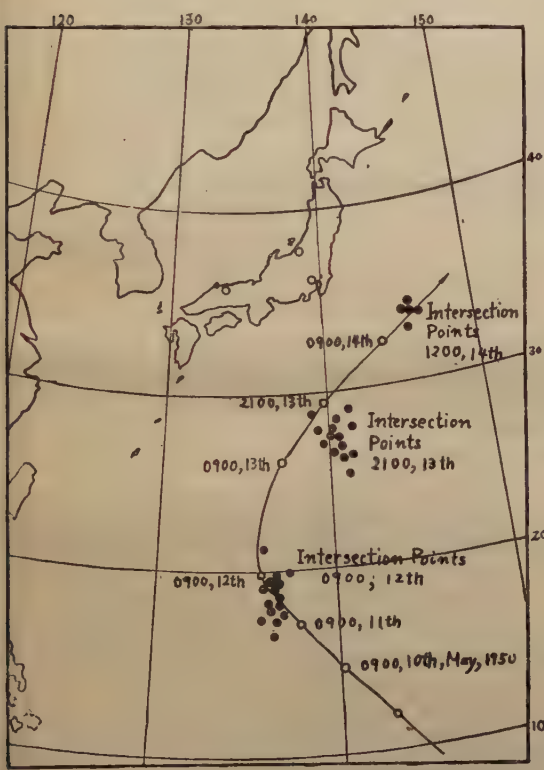

Fig. 5 Course of the typhoon DORIS and atmospherics sources observed in its active area.
● represents intersection points:
○ represents the centre of typhoon.

Acknowledgements

As the observation period was very short, the results, especially on the relation to meteorological phenomena, can be applied only to certain limited cases. But the atmospherics observation stated in this paper may be useful to locate not only thunderstorms but also fronts, depressions or typhoons under some conditions. We will make further study on atmospherics in relation to such meteorological phenomena.

The authors wish to express sincere thanks to many members of C.M.O.; especially to Mr. T. Furuhata, Mr. Z. Yanagisawa Mr. T. Suda for their help in the observation, and to Mr. S. Ooi for his help in the meteorological analysis.

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LETTER TO EDITOR

Intense *Es* Ionization near the Magnetic Equator

Worldwide *Es* ionization was examined from monthly median values of *fEs* at many stations (see Fig. 1). Meridional distributions of *Es* ionization on geomagnetic

Fig. 1 Geographical distribution of ionospheric observatories whose records were examined. Main stations situated within ±40° of magnetic dip are as follows:

C	: Christmas Island	(1.9°N, 157.3°W)
D	: Dakar	(14.6 N, 17.4 W)
G	: Guam Island	(13.6 N, 144.9 E)
H	: Huancayo	(12.0 S, 75.3 W)
L	: Leyte	(11.0 N, 125.0 E)
M	: Maui	(20.8 N, 156.5 W)
P	: Palmyra Island	(5.9 N, 162.1 W)
R	: Rarotonga Island	(21.3 S, 159.8 W)
S	: Singapore	(1.3 N, 103.8 E)
T	: Trinidad	(10.6 N, 61.2 W)

------ : magnetic equator (dip 0°)

——— : geomagnetic equator (dipole equator)

and magnetic latitudes are better arranged than that on geographic latitudes, as well as cases of occurrence-frequencies of *Es* (1) (2). As shown in Fig. 2, it seems *fEs* on geomagnetic latitudes in the day-time (mean values from 09h. to 15h.) distributes proportionally to $\cos\chi$, where χ is the sun's zenith distance. (Curves in the figure are obtained assuming that hour-angles are 0° and the sun's north declinations are respectively 3° and 20° for September and May.)

But, the ionization near the magnetic equator, for example at Huancayo and Christmas Island, is abnormally large, though such a phenomenon does not occur in

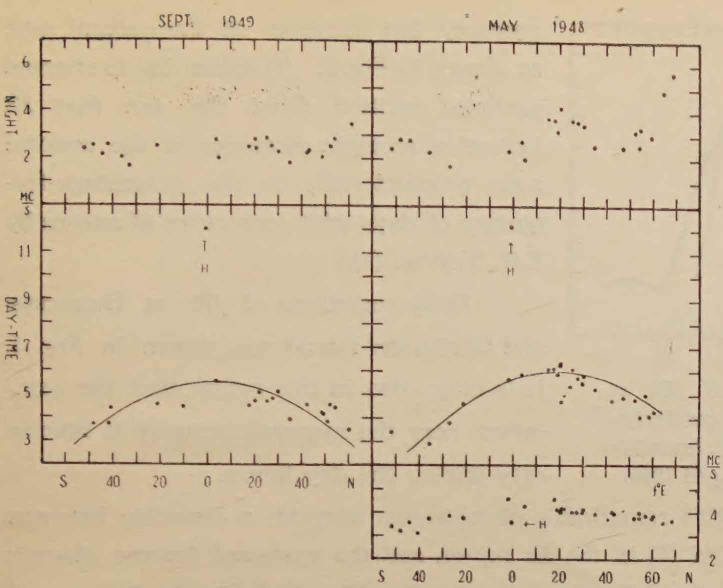

Fig. 2 Distributions of *fEs* on geomagnetic latitudes in the day-time (lower part) and at night (upper part) in September 1949 (left) and May 1948 (right). Curves are respectively 5.5cosχ MC/S and 6.0cosχ MC/S for Sept. and May, where χ is the sun's zenith distance. Bottom of the right part is distribution of f^0E at the day-time in May 1948, and 'H' means Huancayo.

the *E*-layer (see Fig. 2 and Fig. 3). In Fig. 3, this intense *Es* zone centered near the magnetic equator seems to be narrow (difference between Christmas Island and Palmyra Island of neighbouring stations is remarkable), but is not clear whether it surrounds the earth or not. It resembles to the distribution of ranges of daily variation of the horizontal magnetic force by J. Egedal (3).

Es ionization at night (mean values from 22h. to 02h.) is not intense near the magnetic

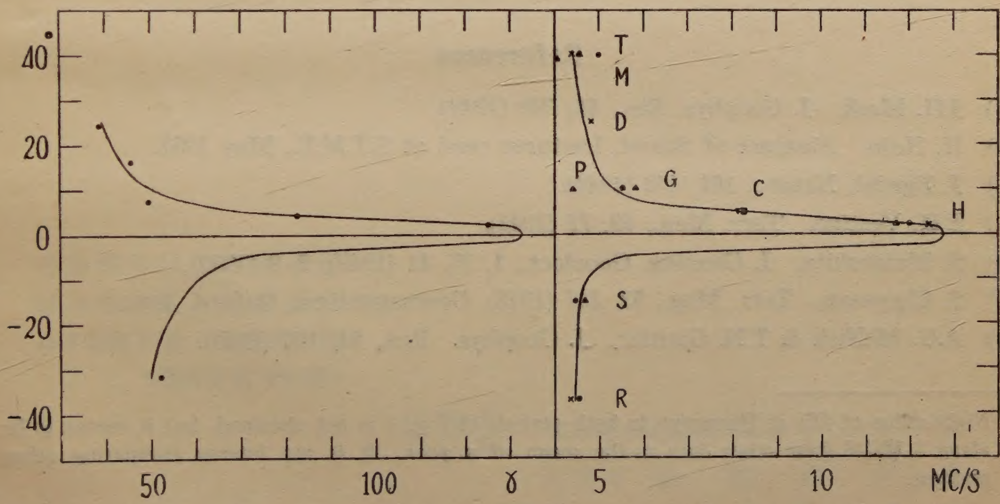

Fig. 3 Distribution of ranges of daily variation of the horizontal magnetic force (left part – after J. Egedal) and distribution of *fEs* in the day-time (right part), near the magnetic equator. Names of stations are shown in Fig. 1.
Ordinate: magnetic dip.

▼ : March 1946 }
■ : April 1946 } (only at Christmas Island for reference)
● : September 1949 ▲ : October 1949 × : March 1950

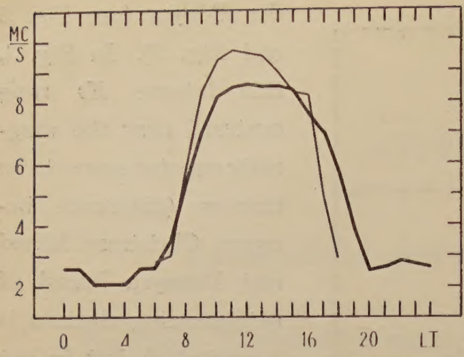

Fig. 4 Daily variations of fEs at Huancayo (fine line) and Christmas Island (big line). (monthly median values of April 1946)

equator,* but increases at the auroral zone as shown in Fig. 2. (It seems due to charged particles emitted from the sun that Es ionization at night increases at the auroral zone proportionally to the percentage-frequency of days with occurrence of aurora by E.H. Vestine (4).)

Daily variations of fEs at Huancayo and Christmas Island are shown in Fig. 4. It is clear also in this figure that the ionization near the magnetic equator is intense only during the day hours.

From these results, this remarkable phenomenon suggests a causality between vertical ionic drift or wind (5) in the Es region and the eastward intense electric current flow that produces the daily magnetic variation (6). And also, the decrease of f^0F_2 in the day-time (7) at this intense Es zone suggests some estimation to this relation.

In conclusion, it is a deep pleasure for the writer to express his sincere thanks to Prof. M. Hasegawa for many helpful suggestions, and also to Miss M. Kato for her assistance.

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* Night-value of fEs at Huancayo in both periods of Fig. 2 is not obtained, but it seems to be about 3 MC/S from other data as the mean of a year. It is not intense comparing other stations.

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